Glossary

A

absolute temperature scale, *T* [e] a temperature scale based on absolute zero, whereby absolute zero (−273.15 °C) is zero kelvin (0 K); **kelvin temperature scale**

absolute zero [e] the lowest possible temperature; −273.15 °C or 0 K

accuracy an expression of how close an experimental value is to the accepted value; often reported as a percent difference

acid [e] a compound that forms electrically conducting aqueous solutions that turn blue litmus red, neutralize bases, and react with active metals to produce hydrogen gas

acid (Arrhenius) [t] a substance that ionizes in water to produce hydrogen ions

acid (modified Arrhenius) [t] a substance that reacts with water to produce hydronium ions

acid (Brønsted–Lowry) [t] a proton donor

acid ionization constant, K_a [e] the equilibrium constant for the ionization of weak acids; also known as the acid dissociation constant

acid–base indicator [e, t] a substance that changes colour in solution when the acidity of the solution changes; a conjugate acid–base pair formed by an indicator dye (large complex molecule)

acidic [e] a solution that turns blue litmus to red and has a pH less than 7; $[H_3O^+(aq)] > [OH^-(aq)]$

activated complex [t] the structural arrangement of atoms/ions believed to represent the highest potential energy point in a chemical potential energy diagram

activation energy, E_a [t] an energy barrier that must be overcome for a chemical reaction to occur; the minimum energy that entities must reach before they can react

active metal [e] a metal that spontaneously reacts with water or an acid to produce hydrogen gas; a metal that is a stronger reducing agent than hydrogen

addition polymerization [t] a reaction in which many unsaturated monomer units with double or triple bonds join together, involving addition reactions

addition reaction [t] a type of organic reaction of unsaturated hydrocarbons in which a small molecule is added to the double or triple bond

alcohol [t] an organic compound containing one or more hydroxyl (−OH) groups as the functional group

aliphatic [t] a broad class of hydrocarbons including straight or branched chains or rings of alkanes, alkenes, and alkynes, but not aromatics

alkali metal [e] a soft, silver-coloured metal that reacts violently with water; a Group 1 element

alkaline see **basic**

alkaline-earth metal [e] a light, reactive metal that forms an oxide coating when exposed to air; in Group 2

alkane [t] one of a family of hydrocarbons whose molecules contain only carbon–carbon single bonds; general formula C_nH_{2n+2}

alkene [t] one of a family of hydrocarbons with one or more carbon–carbon double bonds; general formula of C_nH_{2n}

alkyl branch [t] a group of atoms, consisting of only singly bonded carbon and hydrogen, that is not part of the main structure of the molecule

alkyne [t] one of a family of hydrocarbons with one or more carbon–carbon triple bonds; general formula of C_nH_{2n-2}

ambient conditions surrounding or room conditions

amount concentration, *c* or [...] [e] the chemical amount of solute present in one litre of solution, in units of moles per litre (mol/L); formerly called molar concentration

amount of substance, *n* [e] see **chemical amount**

ampere SI base unit for electric current; 1 A = 1 C/s

amphiprotic [t] an entity having the ability to either accept or donate a proton

amphoteric [e] a chemical substance with the ability to react as either an acid or a base

analogy a comparison that communicates an idea in more familiar or recognizable terms, often related to everyday experiences

analysis the part of an investigation report that includes manipulations, interpretations, and calculations of the Evidence in order to answer the question stated in the Problem

analyze to make a mathematical, chemical, or methodical examination of parts to determine the nature, proportion, function, or interrelationship of the whole; e.g., evidence is analyzed

anecdotal evidence evidence that is based upon personal experience or hearsay

anhydrous the form of a substance without any water of hydration

anion [t] a negatively charged ion

anode [t] the electrode of a voltaic or an electrolytic cell where oxidation (loss of electrons) occurs

aqueous solution [e] a homogenous mixture of one or more solutes dissolved in water; designated as (aq)

aromatic [t] a description of an organic compound with a structure based on benzene or a benzene-like ring

assumption an untested statement presumed to be correct in order to develop or apply a theory, law, or generalization

atmosphere non-SI unit of pressure; 1 atm = 101.325 kPa

atmospheric pressure [e] the force per unit area exerted by air on all objects

atom [t] the smallest entity of an element that is still characteristic of that element

atomic number [t] the characteristic number of protons in the nucleus of an atom of a particular element

Avogadro's constant, N_A [e] the number of entities of a chemical substance in one mole of that substance; estimated at 6.02×10^{23}/mol

Avogadro's theory [t] the statement: *equal volumes of gases at the same temperature and pressure contain equal numbers of molecules*

B

balanced chemical equation [t] a chemical equation in which the total number of each kind of atom or ion in the reactants is equal to the total number of the same kind of atom or ion in the products

barometer a technological device for measuring atmospheric pressure

base [e] a compound that forms electrically conducting aqueous solutions that turn red litmus blue and neutralize acids

base (Arrhenius) [t] an ionic compound that dissociates in water to produce hydroxide ions

base (modified Arrhenius) [t] a substance that reacts with water to produce hydroxide ions

base (Brønsted–Lowry) [t] a proton acceptor

base ionization constant, K_b [e] the equilibrium constant for the ionization of weak bases; also known as the base dissociation constant

basic [e] a solution that turns red litmus to blue and has a pH greater than 7; $[OH^-(aq)] > [H_3O^+(aq)]$

battery a set of two or more electric (or voltaic) cells joined in series to produce a larger voltage

binary ionic compound [t] a compound that contains only two kinds of monatomic ions

binary molecular compound [t] a compound composed of only two kinds of atoms, both of which are nonmetals

bitumen [e] a tarry residue or heavy oil, often found mixed with sand

bond dipole [t] the charge separation that occurs when the electronegativity difference of two bonded atoms shifts the shared electrons, making one end of the bond partially positive and the other partially negative

bond energy [t] the energy required to break a chemical bond; also the energy released when a bond is formed

bonding capacity [t] the maximum number of single covalent bonds that an atom can form; determined by the number of bonding electrons in the atom

bonding electron [t] a single unpaired electron, in a valence orbital, that can be shared or exchanged with another atom

Boyle's law [e] the statement: *as the pressure on a gas increases, the volume of the gas decreases proportionally, provided that the temperature and amount of gas remain constant*; $P_1V_1 = P_2V_2$

branch any group of atoms that are not part of the main (parent) chain of an organic molecule

Brønsted–Lowry concept [t] the idea that the reaction of an acid with a base is a transfer of a proton, H^+, from the acid to the base

Brønsted–Lowry reaction equation [t] a chemical reaction equation written to show an acid–base reaction involving the transfer of a proton from one entity (an acid) to another (a base)

buffer [e] a mixture of a conjugate acid–base pair that maintains a nearly constant pH when diluted or when a strong acid or base is added

buffer capacity [e] the limit of the ability of a buffer to maintain a nearly constant pH

buffer zone [e] a relatively flat region on the pH curve of an acid–base reaction where buffering action occurs; also called the buffering region

burette a long, graduated tube equipped with a stopcock; used to measure solution volumes in a titration

byproduct an additional product (other than the primary product) in a chemical process

C

calorimeter [e] an isolated system in which the chemical system (reactants and products) being studied is surrounded by a known quantity of liquid (generally water)

calorimetry [e] the technological process of measuring energy changes of an isolated system

carboxyl group [t] –COOH; the functional group of carboxylic acids

carboxylic acid [t] an organic compound that contains the carboxyl group (–COOH) as the functional group

catalysis the study of the properties and development of catalysts and their effects on rates of reaction

catalyst [e] a substance that increases the rate of a chemical reaction without being consumed itself in the overall process

catalytic reforming [e] a technological process for converting molecules in a naphtha (gasoline) fraction into aromatic gasoline molecules

cathode [t] the electrode of a voltaic or electrolytic cell where reduction (gain of electrons) occurs

cathodic protection [e] an effective method of preventing corrosion of iron in which the iron is forced to become the cathode by using either an impressed current or a sacrificial anode

cation [t] a positively charged ion

central atom [t] the atom in a molecule that has the most bonding electrons and, therefore, is likely to form the most bonds

certainty an expression of the level of confidence; communicated by a number of significant digits for quantitative values

Charles' law [e] the statement: *as the absolute temperature of a gas increases, the volume increases proportionally, provided that the pressure and amount of gas remain constant*; $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

chemical amount, *n* [e] SI quantity for the number of entities in a substance, measured in units of moles (mol); **amount of substance**

chemical bond [t] the electrical attraction that holds atoms or ions together in an element or compound

chemical change [e] see **chemical reaction**

chemical decomposition [e] the breakdown of a compound into smaller components such as elements (as in **simple decomposition**)

chemical formula [t] a series of symbols representing the atoms/ions, and their proportions, present in a pure substance

chemical potential energy [t] the energy present in the chemical bonds of a substance

chemical potential energy diagram [t] a graphical representation of a chemical reaction in which the difference between the chemical potential energy of the reactants and that of the products is the enthalpy change

chemical reaction [e, t] a change in which one or more new substances with different properties are formed as evidenced by changes in colour, energy, odour, or state; a change in the chemical bonds resulting from the rearrangement of entities (electrons, ions, protons)

chemical reaction equilibrium [t] an apparently static state of a reaction system where the reactants and products may be favoured but the rates of the forward and reverse reactions are equal

chemical technology the study and application of skills, processes, and equipment for the production and use of chemicals

chemistry the physical science that deals with the composition, properties, and changes in matter; the study of chemicals and their reactions, associated technologies, and environmental effects

closed system [e] a chemical system that is separated from its surroundings by a definite boundary so that no matter can enter or leave, but energy can enter and leave (e.g., a capped pop bottle)

coefficient [t] the number, placed in front of a chemical formula in a balanced chemical equation, that represents the number of molecules or formula units of that substance involved in the reaction

collision–reaction theory [t] the idea that chemical reactions involve collisions and rearrangements of entities

colorimetry [e] chemical analysis by colour, using light emitted, absorbed, or transmitted by a solution

combined gas law [e] the statement: *the product of the pressure and volume of a gas sample is proportional to its absolute temperature in Kelvin*; $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

combustion [e] the rapid reaction of a chemical with oxygen to produce oxides and heat; also known commonly as burning

commercial pertaining to companies that use manufactured products to produce other products and processes

compare examine the character or qualities of two things by providing characteristics of both that point out their similarities and differences

complete combustion reaction [e] the burning of a substance with sufficient oxygen available to produce the most common oxides of the elements making up the substance that is burned

compound [e, t] a pure substance that can be separated into its elements by heat or electricity; a substance containing atoms/ions of more than one element in a definite fixed proportion

concentration, *c* [e] a ratio of the quantity of solute to the quantity of solution or solvent; expressed in a variety of units

conclude state a logical end based on reasoning and/or evidence

condensation polymerization [t] a reaction that involves the "condensing out" or removal of a small molecule (such as H_2O, NH_3, or HCl) from the functional groups of two different monomer molecules to form a condensation polymer

condensation reaction [t] an organic reaction in which two smaller molecules combine to form a larger molecule, along with a small molecule such as water; e.g., **esterification reaction**

conductivity [e] a measure of the ability of a substance to conduct an electric current

conjugate acid–base pair [t] a pair of substances with chemical formulas that differ only by a proton

consumer pertaining to an individual in society

control a substance, condition, or procedure that does not change and is used as a comparison in an experiment

controlled variable a property or condition that could vary but is held constant so as not to affect the outcome of an experiment; also known as fixed or restrained variable

coordinate covalent bond [t] a type of covalent bond in which one of the atoms donates both electrons

corrosion [e] an electrochemical process in which a metal reacts with substances in the environment, returning the metal to an ore-like state

coulomb SI unit for the quantity of electric charge transferred in one second by one ampere of current; unit symbol, C

contrast point out the differences between two things that have similar or comparable natures; **distinguish**

covalent bond [t] the simultaneous attraction of two nuclei for a shared pair of bonding electrons

covalent network [t] a three-dimensional arrangement of covalent bonds between atoms throughout a crystal (e.g., quartz, diamond)

cracking [t] a chemical process in which larger (e.g., hydrocarbon) molecules are broken down at high temperature, with or without catalysts, to produce smaller molecules

create–test–use a three-stage process of laboratory work that results in scientific knowledge coming to be accepted with increased certainty

crystal lattice [t] a continuous, three-dimensional pattern of atoms, ions, or molecules in a crystalline solid

crystallization [e] the technological process of separating a solid from a solution by evaporating the solvent or cooling the solution

cycloalkane [t] a cyclic hydrocarbon (molecules have a closed ring structure) in which all the carbon–carbon bonds are single bonds; general formula C_nH_{2n}

cycloalkene [t] a cyclic hydrocarbon with at least one carbon–carbon double bond

D

define provide the essential qualities or meaning of a word or concept; make distinct and clear by marking out the limits

describe give a written account or represent the characteristics of something by a figure, model, or picture

design construct a plan for a specific purpose; for an investigation, an overview of the Procedure including reacting chemicals, diagnostic tests, variables, and controls

determine find a solution, to the required degree of accuracy, to a problem by showing appropriate formulas, procedures, and calculations

diagnostic test a short laboratory procedure with expected evidence and analysis; used to identify or classify substances

diatomic molecule [t] a molecule containing two atoms

dilution [e] the process of adding solvent to a solution to reduce its concentration

dipole [t] a partial separation of positive and negative charges within a molecule, due to electronegativity differences

dipole–dipole force [t] the simultaneous attraction between oppositely charged ends of polar molecules

discharging the spontaneous conversion of chemical energy into electrical energy by a cell or battery

disproportionation [e] the reaction of a single substance with itself to produce two different substances; a type of redox reaction in which an entity is both oxidized and reduced

dissociation [t] a separation and dispersal of previously bonded entities; the separation of ions that occurs when an ionic compound dissolves in water

distinguish point out the differences between two things that have similar or comparable natures; **contrast**

double blind an experimental design where neither the subject nor the experimenter knows whether the subject is in a control group or an experimental group

double bond [t] an attraction between atoms in a molecule due to the sharing of two pairs of electrons in a covalent bond

double replacement reaction [e] a reaction of two ionic compounds in which the cations and anions rearrange, producing two different compounds

dry cell [e] any sealed electric cell with semi-solid contents; originally used to describe the zinc–chloride cell

ductile [e] able to be drawn (stretched) into a wire or a tube

dynamic equilibrium theory [t] the idea that there is a balance between two opposing processes (forward and reverse) occurring at the same rate

E

ecological perspective pro or con statement relating to relationships between living organisms (including human beings) and the environment

economic perspective pro or con statement relating to the production, distribution, and consumption of wealth

electric cell a technological device for converting chemical energy into electrical energy

electric current, *I* a measure of the rate of flow of charge past a point in an electrical circuit; measured by an ammeter in ampères (A)

electric potential difference, *V* the energy difference, per unit charge, between any two points in an electrical circuit; measured in volts (V); also called **voltage**

electrochemical cell a cell that either converts chemical energy to electrical energy (electric or voltaic cell), or electrical energy into chemical energy (electrolytic cell)

electrochemistry the branch of chemistry that studies electron transfers in chemical reactions

electrode [e] a solid electrical conductor

electrolysis [e] the process of supplying electrical energy to force a nonspontaneous redox reaction to occur

electrolyte [e] a substance that conducts electricity in aqueous solution; also a liquid such as a molten solid that conducts electricity

electrolytic cell [e] a cell in which a nonspontaneous redox reaction is forced to occur; a combination of two electrodes, an electrolyte, and an external power source

electron [t] a small, negatively charged subatomic particle; has a specific energy within an atom

electron dot diagram see **Lewis symbol** and **Lewis formula**

electronegativity [t] a number that describes the relative ability of an atom to attract a pair of bonding electrons in its valence level

electroplating [e] a process for depositing a metal onto another object that is the cathode of a cell

electrorefining [e] a process for producing pure metals using an electrolytic cell to deposit the pure metal at the cathode and using the impure metal as the anode

element [e, t] a pure substance that cannot be broken down into simpler chemical substances by any physical or chemical means; consists of only one kind of atom

elimination reaction [t] an organic reaction that involves the removal of atoms and/or groups of atoms from adjacent carbon atoms in an organic molecule (e.g., the removal of H_2O from an alcohol)

emotional perspective a pro or con statement referring to feelings as opposed to logic or reasoning

empirical definition a statement that defines an object or a process in terms of observable properties

empirical formula the experimentally determined simplest whole-number ratio of atoms or ions in a compound

empirical hypothesis a preliminary generalization, regarding observable properties, that requires further testing

empirical knowledge knowledge gained through observation

endothermic reaction [e, t] a chemical reaction that absorbs energy from the surroundings; a change resulting in a higher enthalpy of the chemical system

endpoint [e] the point during a titration when there is a sudden change in some observable property of the solution, such as colour, pH, or conductivity

energy [e] a property of a substance or system that relates to its ability to do work

energy diagram see **chemical potential energy diagram**

energy level [t] a specific energy an electron can have in an atom or ion

enthalpy [t] the total kinetic and potential energy within a system at constant pressure

enthalpy change, ΔH or $\Delta_r H$ [t] the difference between the enthalpy of the products and the enthalpy of the reactants of a chemical reaction

enthalpy of reaction [e] the energy change for a whole chemical system when reactants change to products; also known as change in enthalpy

entity [t] a general term that includes atoms, ions, and molecules

enumerate specify one by one or list in concise form and according to some order

enzyme [e] a compound, usually a protein, that acts as a catalyst in a living system; often responsible for controlling a certain physiological reaction

equilibrium [e] the state of a closed system with no observable changes occurring; having constant macroscopic properties

equilibrium constant, K_c (e) a constant value for a reaction system over a range of concentrations

equilibrium law [e] a mathematical expression relating concentrations of reactants and products to the equilibrium constant, $K_c = [C]^c[D]^d/([A]^a[B]^b)$ where A, B, C, and D represent chemical entity formulas and *a*, *b*, *c*, and *d* represent their coefficients in the balanced chemical equation

equilibrium shift [e] the change in concentrations that occurs when a system at equilibrium is disrupted (e.g., by the addition of more reactant)

equivalence point [t] the point during a titration at which the exact theoretical chemical amount of titrant has been added to the sample

ester [e, t] a family of organic compounds characterized by the **ester functional group** (–COO–); formed from the reaction of a carboxylic acid and an alcohol

ester functional group [t] –COO–; the functional group of esters

esterification reaction [e] a condensation reaction in which a carboxylic acid and an alcohol combine to produce an ester and water

esthetic perspective a pro or con statement relating to beauty

ethical perspective a pro or con statement relating to whether an action is right or wrong

evaluate give the significance or worth of something by identifying the good and bad points or the advantages and disadvantages

evaluation the part of an investigation report that includes judging the validity of the experiment (Design, Materials, Procedure, and Skills), judging the Prediction and authority, and assessing whether the Purpose was achieved

evidence the part of an investigation report that includes all qualitative and quantitative observations related to answering the Problem; data or observations with a scientific purpose

excess reagent [e] the reactant that is still present after a reaction has gone to completion

exothermic reaction [e, t] a chemical reaction that releases energy to the surroundings; a change resulting in lower enthalpy of the chemical system

explain make clear what is not immediately obvious or entirely known; give the cause of or reason for; make known in detail

F

family [e] a set of elements with similar chemical properties; the elements in a vertical column in the main part of the periodic table; also called a **group**

Faraday constant, *F* [e] the quantity of charge transferred for every mole of electrons that flows in the cell; 9.65×10^4 C/mol

Faraday's law [e] the statement: *the mass of an element produced or consumed at an electrode is directly proportional to the time the cell operates, as long as the current is constant or vice versa*

filtrate [e] the solution that flows through a filter paper

filtration the technological process of separating a slightly soluble solid from a mixture using a porous filter paper or medium

flame test [e] a diagnostic test based on the characteristic colours of ions in a flame

formation reaction [e] the reaction of two or more elements to form either an ionic compound (from a metal and a nonmetal) or a molecular compound (from two or more nonmetals)

formula subscript [t] the number of ions or atoms present in one molecule or formula unit of a substance

formula unit [t] the simplest whole number ratio of ions in an ionic compound

forward reaction the left-to-right change in a written chemical equilibrium equation

fossil fuels an energy resource believed to be the accumulated remains of plants and animals from past geologic periods; includes petroleum and coal

fraction [e, t] a product in the fractionation process, identified by its boiling-point range or by the approximate number of carbon atoms in the component molecules

fractionation [e] a technological process in which the components of crude oil are physically separated by means of their differences in boiling points

fuel cell [e] an electric cell that produces electricity by the reaction of a fuel that is continuously supplied to keep the cell operating

functional group [t] a characteristic arrangement of atoms or bonds within a molecule that determines the most important chemical and physical properties of a class of compounds

G

gas stoichiometry [e] the method of predicting or analyzing the quantity of a gas involved in a chemical reaction

gasohol [e] a mixture of gasoline and alcohol used as an automobile fuel

generalization a statement that summarizes a limited number of empirical results

graduated pipette a precise device consisting of a narrow glass tube with regular markings

graphically using a drawing that is produced electronically or by hand and that shows a relationship between certain sets of numbers

gravimetric analysis [e] a chemical analysis that uses stoichiometric calculations based on a measured mass of a reagent

gravimetric stoichiometry [e] the method of predicting or analyzing the masses of reactants and/or products involved in a chemical reaction

green chemistry the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances

greenhouse gas a gas (e.g., carbon dioxide, chlorofluorocarbons, methane), that is released or present in the atmosphere, that serves to trap heat and reduce its transfer into outer space

group [e] a set of elements with similar chemical properties; the elements in a vertical column in the main part of the periodic table; also called a **family**

H

Haber process an industrial process, named after Fritz Haber, that produces ammonia from hydrogen and atmospheric nitrogen

half-cell [e] an electrode–electrolyte combination forming one-half of a complete cell

half-reaction [t] a balanced chemical equation that represents either a loss or gain of electrons by a substance

halogen [e] a reactive nonmetal element from Group 17

heat [e] a form of energy that can only be transferred between substances, never possessed by them

heat of reaction see **enthalpy change**

Hess' law [e] the statement: *the addition of chemical equations yields a net chemical equation whose enthalpy change is the sum of the individual enthalpy changes*; $\Delta_r H° = \sum \Delta_r H°$ (in standard conditions)

heterogeneous mixture [e] a mixture that is non-uniform, and may consist of more than one phase

homogeneous mixture [e] a mixture that is uniform and consists of only one phase; e.g., a solution

homologous series [e] a series of compounds, with similar structures, in which each member differs from the next by a constant unit (e.g., CH_2)

hydrate [e, t] a pure substance that decomposes at a relatively low temperature to produce water and another substance; a substance containing loosely bonded water molecules

hydrocarbon [t] a compound containing only carbon and hydrogen atoms

hydrocarbon derivative [t] a molecular compound of carbon and, usually, hydrogen plus at least one other element (e.g., organic halides, alcohols)

hydrocracking [e] a technological process involving a combination of catalytic cracking and hydrogenation that is used to reduce heavier feedstocks to, for example, gasoline-type molecules

hydrogen bond [t] the simultaneous attraction of a hydrogen nucleus (a proton), that is covalently bonded to a very electronegative atom, for a lone pair of electrons on an adjacent molecule; generally involves molecules with F–H, O–H, and/or N–H bonds

hydrogenation [t] an addition reaction in which hydrogen is added to an unsaturated hydrocarbon to reduce the number of multiple bonds

hydronium ion [t] a hydrated hydrogen ion (proton), $H_3O^+(aq)$; the entity responsible for acidic properties in aqueous solutions

hydroxyl group [t] –OH; the functional group for alcohols

hypothesis a preliminary empirical or theoretical concept that provides a possible explanation for a natural or technological phenomenon, and that requires further testing

I

ICE table a table used to record the *initial*, *change*, and *equilibrium* concentrations of reactants and products in solution

ideal gas [e, t] a gas that obeys all the gas laws perfectly under all conditions; a hypothetical gas with molecules of negligible size and no intermolecular forces between the molecules

ideal gas law [e] the statement: *the product of pressure and volume of a gas is directly proportional to the chemical amount and absolute temperature*; $PV = nRT$

identify recognize and select as having the characteristics of something

illustrate make clear by giving a specified example

indicator see **acid–base indicator**

industrial pertaining to large-scale companies that usually deal with natural raw materials

inert electrode [e] an unreactive solid conductor in a cell that provides a location to connect a wire and a surface on which a half-reaction can occur

infer form a generalization from sample data; arrive at a conclusion by reasoning from evidence

intermediate [e] a chemical entity that forms with varying stability at the end of a step in a reaction mechanism

intermolecular force [t] the relatively weak forces of attraction and repulsion between molecules

interpret tell the meaning of something; present information in a new form that adds meaning to the original data

interpretation an indirect form of knowledge that builds upon a concept or an experience to further describe or explain an observation

intramolecular force [t] the relatively strong bonds or forces of attraction and repulsion within a molecule; typically covalent bonds

ion [t] an entity with a net positive or negative electrical charge due to the loss or gain of one or more electrons

ionic bond [t] the simultaneous attraction among positive and negative ions

ionic compound [e, t] a pure substance formed from a metal and a nonmetal; a crystalline solid at SATP with a relatively high melting point and a conductor of electricity in aqueous or molten states; a compound containing positive and negative ions

ionic formula [t] a group of chemical symbols representing the simplest whole number ratio of ions in the compound

ionization [t] a process by which a neutral atom or molecule is converted to an ion; the reaction of substances in water to create ions

ionization constant for water, K_w [e] the equilibrium constant in the water ionization equilibrium; $K_w = [H_3O^+(aq)]\,[OH^-(aq)]$, calculated with amount concentration units

isoelectronic molecules [t] molecules having the same total number of electrons

isolated system [e] a system in which neither matter nor energy can move in or out; used to study energy changes (e.g., a calorimeter)

isomers compounds with the same molecular formula but with different structures

IUPAC International Union of Pure and Applied Chemistry; the organization that establishes the conventions used by chemists

J

joule SI unit for energy of all kinds (J)

justify show reasons for, or give facts that support, a decision

K

Kelvin temperature scale see **absolute temperature scale**

kinetic energy [t] a form of energy related to the motion of a particle

kinetic molecular theory [t] the idea that the smallest entities of a substance—atoms, ions, or molecules—are in continuous motion, colliding with each other and objects in their path

L

law [e] see **scientific law**

law of combining volumes [e] the statement: *when measured at the same temperature and pressure, volumes of gaseous reactants and products of chemical reactions are always in simple ratios of whole numbers*

law of conservation of mass [e] the statement: *in any physical or chemical change, the total initial mass of reactant(s) is equal to the total final mass of product(s)*

Le Châtelier's principle [e] the statement: *when a chemical system at equilibrium is disturbed by a change in a property of the system, the system always appears to react in the direction that opposes the change, until a new equilibrium is reached*

legal perspective a pro or con statement relating to the laws of the land

Lewis formula [t] a chemical formula that shows all valence electrons in shared or lone pairs around each atom in a molecule or polyatomic ion

Lewis symbol [t] a simple model of the arrangement of valence electrons in atoms or monatomic ions in which the symbol for the element represents the nucleus plus all the inner electrons, and single or paired dots represent the valence electrons

limiting reagent [e] the reactant that is completely consumed in a reaction

line structural formula [t] a representation of an organic molecule using line segments to show the hydrocarbon portion where the intersections and ends of the line segments represent carbon atoms with the appropriate number of hydrogen atoms

London force [t] the simultaneous attraction between a momentary dipole in a molecule and the momentary dipoles in the surrounding molecules; strength depends on the number of electrons (and protons) in a molecule

lone pair [t] two valence electrons occupying the same orbital

M

main group element [e] an element in Groups 1, 2, or 12 to 18; best follows the periodic law

malleable [e] able to be hammered into a thin sheet; e.g., a metal

manipulated variable the property that is deliberately and systematically changed in an experiment to see what effect the change will have on another property; also known as the independent variable

mass number [t] the sum of protons and neutrons in the nucleus of an atom or monatomic ion

materials section of an investigation report that provides a complete list of equipment and chemicals, including sizes and quantities

matter [e] anything that has mass and occupies space; may be a pure substance or a mixture

metal [e] an element that is shiny, bendable, and a good conductor of electricity

metallic bond [t] the simultaneous attraction between positive nuclei and mobile valence electrons in a metal

metallurgy [e] the technological process of extracting metals from their naturally occurring compounds and adapting these metals for useful purposes

miscible [e] a term used to describe liquids that dissolve completely in each other in any proportion

mixture [e] matter whose composition includes two or more substances and may or may not be uniform throughout the sample; i.e., homogeneous or heterogeneous

model physical, graphic, or mental representation used to communicate an abstract idea

molar enthalpy of reaction, $\Delta_r H_m$ [e] the enthalpy change in a chemical system per mole of a specified chemical undergoing change in the system

molar mass, M [e] the mass of one mole of a substance in units of grams per mole (g/mol)

molar volume, V_m [e] the volume occupied by one mole of a gas at a specified temperature and pressure in units of litres per mole (L/mol)

mole [t] the SI base unit for the chemical amount or amount of a substance, where one mole is the number of entities corresponding to Avogadro's constant; unit symbol, mol

molecular compound [e, t] a pure substance that may be a solid, liquid, or gas at SATP, has a relatively low melting point, and is non-conducting in any state; a compound that consists of covalently bonded nonmetal atoms

molecular formula [t] a group of chemical symbols indicating the type and number of nonmetal atoms in a single molecule

molecular prefixes a list of prefixes recommended by IUPAC to specify the number of atoms in molecule or water molecules in a hydrate

molecule [t] an entity consisting of a group of nonmetal atoms held together by covalent bonds

momentary dipole [t] an uneven distribution of electrons around a molecule, resulting in a temporary charge difference between its ends

monatomic ion [t] a positively or negatively charged particle formed from a single atom by the loss or gain of electrons; also known as a simple ion

monomer [t] a small molecule that links with many other similar molecules, in an addition or a condensation reaction, to form a polymer

monoprotic acid [t] an acid that possesses only one ionizable (acidic) proton, HA, and can react only once with water to produce hydronium ions

monoprotic base [t] a base that can react with water only once to produce hydroxide ions

MSDS Material Safety Data Sheets; publications detailing the properties, safe handling, and disposal techniques for chemicals

multiperspective view a view that is based upon many perspectives on an issue, including both pro and con statements from each perspective

multi-valent [t] the ability of an atom to form a variety of ions

N

net ionic equation [t] a chemical reaction equation that includes only reacting entities (molecules, atoms, and/or ions) and omits any that do not change

neutral [t] having neither acidic nor basic properties; *or* having a net charge of zero (electrically neutral)

neutralization [e, t] a type of double replacement reaction in which an acid reacts with a base to produce water and an ionic compound; a reaction between hydronium and hydroxide ions to produce water

neutron [t] an uncharged subatomic particle present in the nuclei of most atoms

noble gas [e, t] a very unreactive gaseous element from Group 18; an element with a full shell of valence electrons

nomenclature a systematic method for naming something; chemical nomenclature is governed by the IUPAC

nonelectrolyte compounds that do not conduct electricity in aqueous solution nor in the molten/liquid state

nonmetal [e] an element that is not shiny, not bendable, and generally not a good conductor of electricity

nonpolar covalent bond [t] a bond in which the electrons are shared equally because the bonded atoms have the same electronegativity

nonpolar molecule [t] a molecule in which the negative (electron) charge is distributed symmetrically among the atoms making up the molecule

nuclear change [t] a change within the nucleus of an atom/ion that creates one or more new atoms/ions; represented by a change in atomic symbols

O

observation a direct form of knowledge obtained by means of one of the five human senses—sight, smell, taste, hearing, or touch—or with the aid of an instrument, such as a balance

octet rule [t] the idea that a maximum of eight electrons (four pairs) can occupy orbitals in the valence level of an atom

open system [e] a system in which both matter and energy can move in or out (e.g., an open bottle of pop)

orbital [t] a region of space around the nucleus of an atom where an electron of particular energy is likely to be found; may contain 0, 1, or 2 electrons

organic chemistry a major branch of chemistry that deals with compounds of carbon, excluding oxides and ionic compounds of carbon-based ions such as carbonate, cyanide, and carbide ions

organic halide [t] an organic compound in which one or more hydrogen atoms have been replaced by halogen atoms; the functional group is the halogen atom

outline give, in the requested format, the essential parts of something

oxidation [t] a chemical process involving the loss of electrons by an entity; an increase in the **oxidation number**

oxidation number a positive or negative number corresponding to the oxidation state assigned to an atom or ion

oxidizing agent [t] an entity that causes oxidation by removing (gaining) electrons from another substance in a redox reaction

P

Pascal SI unit of pressure; 1 Pa = 1 N/m^2

percent difference the ratio of the difference between experimental and predicted values to the predicted value; a measure of the accuracy of the experimental value

percent yield the ratio of the difference between the actual or experimental quantity of product obtained (actual yield) and the maximum possible quantity of product (predicted or theoretical yield obtained from a stoichiometry calculation) to the maximum quantity

period [e] a horizontal row of elements in the periodic table whose properties gradually change from metallic to nonmetallic from left to right along the row

periodic law [e] the observation that chemical and physical properties of elements repeat themselves at regular intervals when the elements are arranged in order of increasing atomic number

peripheral atom [t] atoms surrounding the central atom in a molecule or polyatomic ion

perspective a point of view; a way of looking at an issue, pro or con

petrochemical a chemical made from petroleum

petroleum a complex mixture of hydrocarbons; natural gas and various types of oil

pH a measure of the acidity of a solution as the negative exponent to the base ten of the hydronium ion concentration; pH = $-\log[H_3O^+(aq]$

pH curve [e] a graph showing the continuous change of pH versus the volume of titrant during an acid–base reaction

phase equilibrium [e] a type of equilibrium that involves a single chemical substance existing in more than one phase (state) in a closed system

phenyl group [t] C_6H_5–; a benzene ring attached as a branch of a parent chain

photosynthesis [e] the formation of carbohydrates and oxygen from carbon dioxide, water, and sunlight, catalyzed by chlorophyll in the green parts of a plant

physical change [e] any change in the form of a substance in which the chemical composition does not change

pipette a glass tube used to measure precise volumes of solution

placebo in drug studies, an inactive item (e.g., sugar pill) or treatment given to the control group for comparison to the experimental group

pOH a measure of the basicity of a solution as the negative exponent to the base ten of the hydroxide ion concentration; pOH = $-\log[OH^-(aq)]$

polar covalent bond [t] a bond in which the bonding electrons are not shared equally because the bonded atoms have different electronegativities

polar molecule [t] a molecule in which the negative charge is not distributed symmetrically among the atoms, resulting in partial positive and negative charges on opposite ends of the molecule

political perspective a pro or con statement relating to vote-getting actions or campaigning

polyamide [t] a polymer in which the monomers—one with two carboxyl groups (–COOH) and one with two amine groups ($–NH_2$), react to form amide linkages (–CONH–)

polyatomic ion [t] a group of atoms with a net positive or negative charge on the whole group

polyester [t] a polymer in which the monomers—one with two carboxyl groups (–COOH) and one with two alcohol groups (–OH)—react to form ester linkages (–COO–)

polymer [t] a large molecule made by linking together many smaller molecules called **monomers**

polymerization [e] the process of forming polymers from the reaction of monomers; e.g., addition and condensation polymerizations

polypeptide [t] a polymer made up of amino acid monomers joined with peptide (–CONH–) linkages; a protein is a polypeptide that is more than about fifty amino acids long

polyprotic acid [t] an acid with more than one acidic hydrogen available to react with water to form hydronium ions; an acid that can donate more than one proton

polyprotic base [t] a base that can react more than once with water to form hydroxide ions; a base that can accept more than one proton

potential energy [t] a stored form of energy dependent on the relative positions of particles in a system

porous boundary [e] a physical barrier separating two electrolytes while still permitting ions to move between the two solutions through tiny openings

ppm parts per million; the symbol for a unit of concentration corresponding to 1 g/10^6 g or 1 mg/kg

precipitate [e] a solid substance(s) formed during a reaction in solution

precipitation [e] a type of double replacement reaction in which a precipitate forms

precision a measure of the reproducibility or consistency of a result; in a simplified approach, precision can be measured as the place value of the last measurable digit from an instrument

predict tell in advance on the basis of empirical evidence and/or logic

prediction the expected answer (usually to the Problem in an investigation) according to some scientific concept or other authority, and including the reasoning

pressure, *P* the force per unit area measured in SI units of pascals (Pa); 1 Pa = 1 N/m^2

primary cell a cell that cannot be recharged, usually due to irreversible side reactions

primary standard [e] a chemical that can be obtained at high purity, with a mass that can be measured to high accuracy and precision

problem the part of an investigation report that states the specific question to be answered, in terms of manipulated and responding variables where possible

procedure the part of an investigation report that is a numbered, sequential list of directions necessary to obtain the evidence needed to answer the problem

products the substances produced by a chemical reaction; substances whose chemical formulas appear to the right of the arrow in a chemical reaction equation

proteins natural polymers of amino acids forming the basic material of living things

proton a positively charged subatomic particle found in the nucleus

pseudo-scientific falsely represented as scientific knowledge or process

pure substance [e] matter whose composition is constant and uniform; composed of only one kind of chemical

purpose the stated reason for doing a scientific investigation, usually to gather evidence to create, test, or use a scientific concept

Q

qualitative analysis [e] the identification of a specific chemical substance

qualitative observation [e] an observation that describes qualities of matter or changes in matter (e.g., odour, colour, and physical state); observation with no numerical value

quantitative analysis [e] the determination of the quantity of a substance present

quantitative observation [e] an observation that involves one or more measurements of some property; observation with numerical value

quantitative reaction a reaction in which more than 99% of the limiting reagent is consumed

quantum mechanics [t] a current theory of atomic structure in which electrons are described in terms of their energy and the probability patterns

R

random error an uncertainty that is non-systematic and related to measuring or sampling errors

reactants the substances being consumed in a chemical reaction; substances whose chemical formulas appear to the left of the arrow in a chemical reaction equation

reaction mechanism [t] a sequential list of chemical reaction equations that describes the individual reaction steps and intermediates formed from the initial reactants to the final products

reagent a chemical, usually relatively pure, used in a reaction

real gas [e] an actual gas that condenses when cooled and deviates from the gas laws under certain conditions

recharging the nonspontaneous conversion of electrical energy to chemical energy in a cell

redox reaction [t] a **red**uction–**ox**idation reaction; a chemical reaction in which electrons are transferred between entities

redox spontaneity rule [e] the generalization: *a spontaneous redox reaction occurs only if the oxidizing agent (OA) is above the reducing agent (RA) in a table of relative strengths of oxidizing and reducing agents with reduction potentials*

reducing agent [t] an entity that causes reduction by donating (losing) electrons to another substance in a redox reaction

reduction [t] a chemical process involving the gain of electrons by an entity; a decrease in the oxidation number

reference energy state a reference point at which the potential energy of elements in their most stable form at SATP is defined as zero

reference half-cell a half-cell that is chosen as a reference and arbitrarily assigned an electrode potential of exactly zero volts; a standard hydrogen electrode

refereed journal an academic publication where research papers are sent to peers (subject experts) for review and evaluation before publication

refining [e] the technology that includes physical and chemical processes for separating complex mixtures into simpler mixtures or near-pure components

reforming [e] the technological process of converting molecules into larger or more branched molecules

relate show logical or causal connection between things

responding variable the measured property that changes in response to the change in the manipulated variable; also known as dependent variable

reverse reaction usually in reference to the right–to–left change in an equilibrium equation

roasting [e] the technological process of reacting metal sulfides with oxygen to form metal oxides and sulfur dioxide

S

sacrificial anode [e] a metal that is more easily oxidized than iron and is connected to the iron object to be protected

salt bridge [e] a tube or connection containing an inert electrolyte that connects two half-cells in a voltaic cell

sample [e] a selected or measured part of the whole; e.g., the fixed volume of solution in a titration analysis

SATP standard ambient temperature and pressure; 25 °C and 100 kPa

saturated hydrocarbon [t] a compound of carbon and hydrogen whose molecules contain only carbon–carbon single bonds

saturated solution [e] a solution in which no more solute will dissolve at a specified temperature; at maximum solute concentration

science the study of the natural and technological world with the goal of describing, explaining, and predicting substances and changes

scientific perspective a pro or con statement relating to researching (describing, explaining, and predicting) natural and technological phenomena

scientific law a major empirical concept that is based on a large body of empirical knowledge

secondary cell a rechargeable cell

semi-metal a class of elements that are distributed along the "staircase line" in the periodic table; also called metalloids

significant digits all digits in a measured or calculated value that are certain plus one estimated (uncertain) digit

simple decomposition reaction [e] the breakdown of a compound into its component elements

single bond [t] an attraction between atoms in a molecule due to the sharing of a single pair of electrons in a covalent bond

single replacement reaction [e] the reaction of an element with a compound to produce a new element and a new compound

sketch provide a drawing that represents the key features of an object or graph

social perspective a pro or con statement referring to the effects on human communities

solubility [e] the concentration of a saturated solution at a specified temperature

solubility equilibrium [e, t] a constant state of a system in which excess solute is in contact with the saturated solution; the rate of dissolving equals the rate of crystallizing

solute [e] a substance that is dissolved in a solvent

solution [e] a homogenous mixture of substances composed of at least one solute and one solvent

solution stoichiometry [e] the method of predicting or analyzing the volume and concentration of solutions involved in a chemical reaction

solve give a solution for a problem

solvent a substance (usually a liquid) in which a solute is dissolved to form at solution

solvent extraction [e] a process in which a solvent is added to selectively dissolve and remove part of a mixture

specific heat capacity, *c* [e] the quantity of energy required to raise the temperature of a unit mass of a substance by one degree Celsius or one Kelvin

spectator ion [t] an ion that is present but does not take part in a chemical reaction

spontaneous occurring naturally without any external energy source

standard cell a voltaic cell in which each half-cell contains all entities shown in the half-reaction equation at SATP conditions, with a concentration of 1.0 mol/L for the aqueous solutions

standard cell potential, E°_{cell} [e, t] the maximum electrical potential difference (voltage) of the cell operating under standard conditions; the energy difference (per unit of charge) between the cathode and the anode

standard enthalpy of formation $\Delta_f H°$ [e] the enthalpy change calculated from measurements of a formation reaction under standard conditions

standard molar enthalpy of reaction, $\Delta_r H_m°$ [e] the molar enthalpy of reaction determined when the initial and final conditions of the chemical system are standard conditions

standard reduction potential, $E°_r$ [t] the ability of a standard half-cell to attract/gain electrons under standard conditions

standard solution [e] a solution with a concentration that is known with considerable certainty; a solution of accurate concentration

standardizing [e] the process of determining the concentration of a solution by reacting it with another solution that has been prepared from a primary standard

state of matter [e] the physical form of a substance such as solid (s), liquid (l), gas (g), or aqueous solution (aq)

stereochemical formula a chemical formula that represents the three-dimensional shape of the molecule

stereochemistry the study of the 3-D spatial configuration of molecules and how this affects their reactions

stock solution [e] an initial, usually concentrated, solution from which samples are taken for dilution

stoichiometric a condition in which a reaction can be represented by a fixed and reliable mole ratio from a balanced chemical equation

stoichiometry [e] a method for predicting or analyzing the quantities of reactants and products involved in a chemical reaction

STP standard temperature and pressure; 0 °C and 1 atm (101.325 kPa)

strong acid [e, t] a substance that forms a solution with strong acidic properties, such as a low pH; a substance that reacts completely (>99%) with water to form hydronium ions

strong base [e, t] a substance that forms a solution with strong basic properties, such as high electrical conductivity and a very high pH; an ionic hydroxide that dissociates completely (>99%) to release hydroxide ions

structural formula [t] a representation of a molecule in which each covalent bond is shown as a single, double, or triple line (representing single or multiple bonds) between symbols representing bonding atoms

structural isomer [t] a compound with the same molecular formula but with a different structure as another compound

STS science, technology, and society

substitution reaction [t] an organic reaction that involves breaking a carbon–hydrogen bond in an alkane or aromatic ring and replacing the hydrogen atom with another atom or group of atoms

summarize give a brief account of the main points

surroundings [e] the environment around a chemical system

sustainable development development that meets the needs of the present generation without negatively affecting the ability of future generations to meet their own needs

systematic error an uncertainty that is inherently part of a measuring system, instrument, or design

T

technological perspective a pro or con statement referring to the development and use of machines, instruments, and processes that have a social purpose

technology the skills, processes, and equipment required to manufacture useful products or to perform useful tasks

temperature [t] an indirect measure of the average kinetic energy of molecules in a sample

theoretical definition a general statement that characterizes the nature of a substance or a process in terms of non-observables

theoretical description a specific descriptive statement based on theories or models

theoretical hypothesis a theoretical concept that is untested or extremely tentative

theoretical knowledge knowledge that explains and describes scientific observations in terms of non-observables

theoretical yield the maximum quantity of product that can be produced, predicted from the stoichiometry of the chemical reaction

theory a concept or set of ideas that explains a large number of observations in terms of non-observables

thermal energy, Q [t] the total kinetic energy of the entities of a substance; $Q = mc\Delta t$

thermal stability [e] the tendency of a compound to resist decomposition when heated

thermochemistry the study of the energy changes that take place during chemical reactions

titrant [e] the solution that is added from a burette during a titration analysis

titration [e] a technological process of carefully adding a solution (**titrant**) from a burette into a measured, fixed volume of another solution (**sample**) until the reaction is judged to be complete; often uses an indicator to indicate the endpoint

titration analysis [e] a chemical analysis that uses stoichiometric calculations based on a known concentration and measured solution volumes

transition element [e] an element in Groups 3 to 11

triple bond [t] an attraction between atoms in a molecule due to the sharing of three pairs of electrons in a covalent bond

U

universal gas constant, *R* [e] the constant used in the ideal gas law; usually 8.314 (kPa•L)/(mol•K)

unsaturated compound [t] an organic compound containing double or triple carbon–carbon bonds

V

valence electron [t] an electron in the highest energy level of the atom; an electron available for a covalent bond or electron exchange

valence orbital [t] the volume of space that can be occupied by valence electrons in the highest energy level of an atom

van der Waals forces [t] weak attractive forces that molecules exert on each other, including **London** and **dipole–dipole forces**

verify establish, by substitution for a particular case or by geometric comparison, the truth of a statement

volt SI unit of electric potential difference; 1 V = 1 J/C

voltage see **electric potential difference**

voltaic cell [e] an arrangement of two half-cells, separated by a porous boundary, that spontaneously produces electricity

volumetric pipette a glass tube used to measure precise volumes of a liquid; also known as a delivery pipette

VSEPR theory [t] the **V**alence-**S**hell-**E**lectron-**P**air-**R**epulsion theory; a theory for predicting and explaining the shape of a molecule based on the electrical repulsion of bonded and unbonded (lone) electron pairs in a molecule

W

weak acid [e, t] a substance that forms a solution with weak acidic properties, such as a pH slightly below 7; a substance that reacts incompletely (<50%) with water to form relatively few hydronium ions

weak base [e, t] a substance that forms a solution with weak basic properties, such as low electrical conductivity and pH slightly above 7; an ionic or molecular substance that reacts partially (<50%) with water to produce relatively few hydroxide ions

WHMIS Workplace Hazardous Materials Information System, used to communicate chemical hazards

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[e] empirical definition

[t] theoretical definition